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Miscellaneous Data and Information Collected During Radiation Surveys at the Former Monument Uranium Mill Site (1974-1975)

Office of Radiation Programs, Las Vegas, NV

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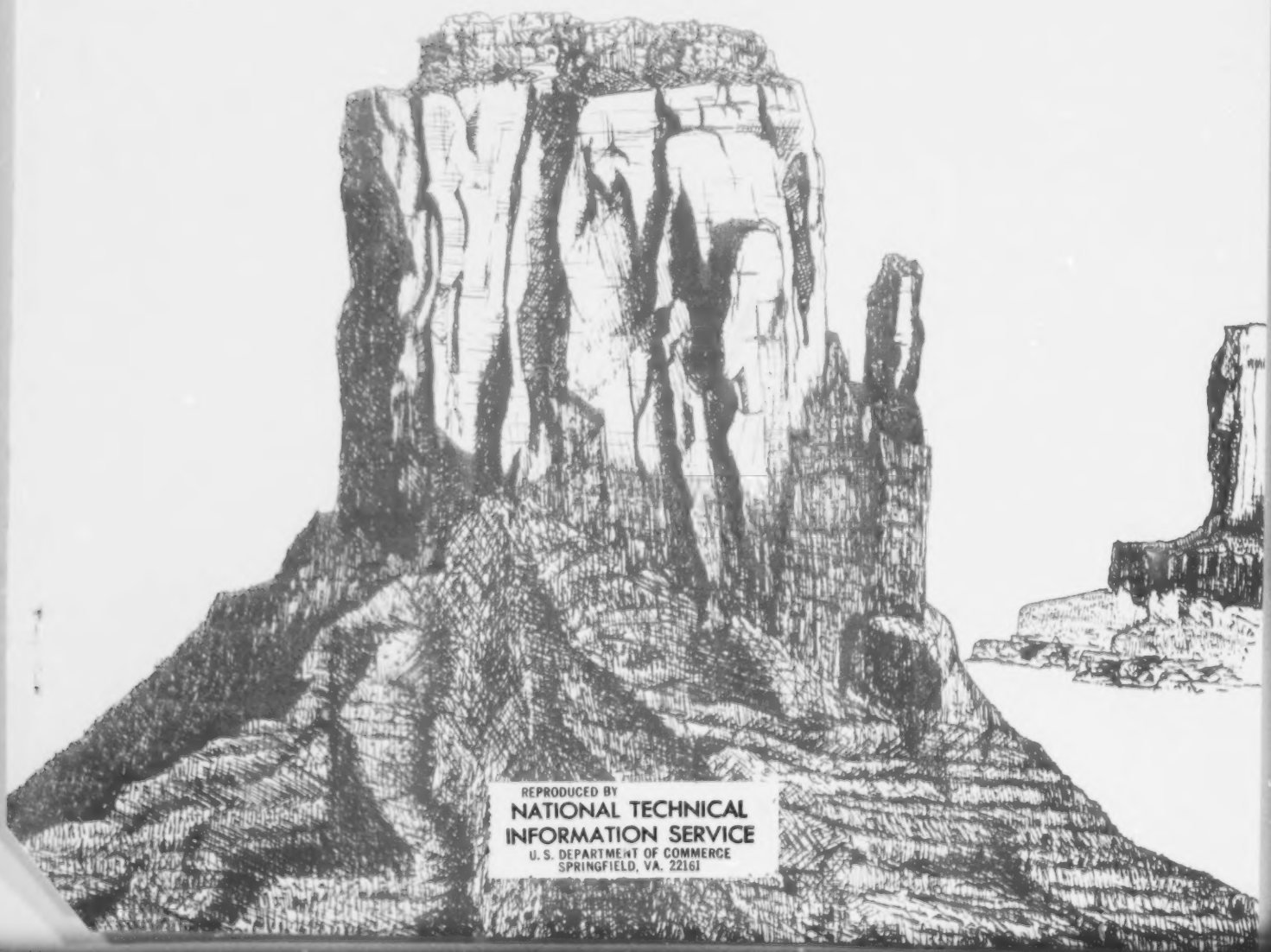

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16. ABSTRACT

During April 1974, staff from the U.S. Environmental Protection Agency and the U.S. Public Health Service/Indian Health Service conducted radiation surveys at four inactive uranium mill sites on the Navajo Reservation. The purpose of the surveys was to delineate the spread and depth of ore and mill tailings in order that cost estimates could be made for their removal and interim stabilization of the tailings piles. The results of the surveys were prepared in summary form and very little data was made available. This report presents the data and information collected at the former Monument Uranium Mill site. The data includes gamma radiation background measurements, bore hole logging data, ground water analysis, gamma surveys, and radionuclide concentrations versus depth in soil. Interpretation of the data is made where possible. It appears, from bore hole logs, that a substantial amount of uranium is still present at the mill site.

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MISCELLANEOUS DATA AND INFORMATION COLLECTED DURING RADIATION SURVEYS AT THE FORMER MONUMENT URANIUM MILL SITE (1974-1975)

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July 1978

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PREFACE

The Office of Radiation Programs (ORP) of the U.S. Environmental Protection Agency (U.S. EPA) carries out a national program designed to evaluate population exposure to ionizing and non-ionizing radiation, and to promote the controls necessary to protect the public health and safety. In April 1974, staff from the Office of Radiation Programs, Las Vegas Facility (ORP-LVF) and from the U.S. Public Health Service-Indian Health Service (U.S. PHS-IHS) conducted a radiation survey at the former Monument Uranium Mill Site. The purpose of this report is to make ancillary data, obtained during the surveys, available in published literature in order to expand the data base related to uranium mining and milling. Readers of this report are encouraged to inform the authors of any omissions or errors. Comments or requests for further information are also invited.

Donald W. Hendricks

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INTRODUCTION

At the request of the Navajo Tribal Chairman and the U.S. PHS-IHS, radiation surveys were conducted in 1974 at four inactive uranium mill sites on the Navajo Reservation. The primary purpose of these surveys was to provide an information base on which cost estimates could be made for the decontamination of the mill site areas and the interim stabilization of their tailings piles. Data gathering for the information base addressed the location and depth of the eroded tailings and the dispersal of uranium ore.

The surveys indicated that extensive wind and water erosion of the tailings had occurred around the mill sites and that ore remains also contributed to the contamination of the environs. A summary of the survey results, including general recommendations for the site decontamination and interim stabilization of the tailings piles, was prepared and forwarded to Tribal officials (Hans, 1974). The techniques, survey equipment, and specific survey results were reported later (Douglas and Hans, 1975).

During the course of the surveys, many measurements were made and samples taken to support the findings and conclusions made for each site. Since only the summaries of the surveys were published, all of the measurements and sample results were not reported in the literature. This report contains data and measurements not previously reported. It will augment the data base concerning uranium mill sites and provide additional information to those organizations that manage and regulate the sites. All data and measurements listed and discussed apply to the former Monument Uranium Mill Site.

SUMMARY

Two radiation surveys were conducted at the former Monument Uranium Mill Site by staff from the Office of Radiation Programs-Las Vegas Facility, U.S. Environmental Protection Agency, and the U.S. PHS-IHS Window Rock, Arizona, Area Office. The first survey was conducted in April 1974 to determine the spread and depth of mill tailings and ore around the site caused by wind and water erosion. The second survey, conducted in April 1975, was to investigate the extent and use of mill tailings and uranium ore for construction in dwellings around the mill site.

All of the data, measurements, and analytical results collected during the surveys were not reported in the literature because the survey results were reported in summary form and part of the analytical results were not available for both survey reports. Miscellaneous data and measurements not available or used in the previous reports are presented and interpreted, where possible, in this report.

Although the wind and water erosion of tailings and ore is evident at the former Monument site, the extent is minimal when compared to other inactive mill sites (Douglas and Hans, 1975). The primary reason for this is that the slimes were hauled away to other mill sites for processing. Since the slimes contain a major portion of the radioactivity and are also very fine particulates, they were not available for erosion. The remaining tailings sands are coarse and tend to resist erosion.

The analysis of well water collected in the vicinity of the mill site did not reveal any excessive radionuclide concentrations. Well 1, located nearest to the mill site, did exhibit a signifi-

cantly different radium-226 concentration than the other wells sampled. This is probably due to the fact that the well is artesian and taps a different ground-water source than the other wells. According to the local residents, this well was drilled to supply water for the operation of the mill.

Wind eroded contaminants around the tailings areas are generally limited to the first few centimeters of topsoil. From profile data, however, it appears that some leach losses have occurred to the northeast of the new tailings pile.

During the April 1974 survey, it was noted that the diked area east of the new tailings pile exhibited substantially higher gamma radiation levels than other areas around the site. An analysis of bore hole logs in this area indicates that the diked area contains in excess of 3 Ci of radium-226. It is also estimated that there may be as much as 11 short tons of uranium in the diked area as a result of batch leach dumping. Further exploration of the diked and the heap leach areas seems to be warranted in order to assess the feasibility of recovering the potential uranium values remaining on the mill site.

SITE DESCRIPTION

LOCATION

The former Monument uranium ore upgrading mill is located on the Navajo Indian Reservation. Specifically, the site is located in Cane Valley, immediately to the east of Monument Valley, at 36°55'45" North latitude and 109°53' West longitude in unsurveyed Section 21, Township 41 North, Range 23 East, Gila and Salt River Meridian, Apache County, Arizona (Figure 1). The Arizona-Utah border is about five miles north of the site; and Mexican Hat, Utah, is approximately 18 miles to the northwest.

TOPOGRAPHY

Cane Valley is bordered on the east by Comb Ridge, which runs in a north-south direction. The cliffs and ridges west of the site form the eastern boundary of Monument Valley. The elevation of the mill site and tailings pile is approximately 4,900 feet above sea level. The total site comprises about 90 acres, and the land surrounding the site is barren and arid with sparse vegetation.

There are two tailings areas on the site, the old tailings area and the new tailings pile, which are approximately 500 feet apart. The old tailings area contains the residue of the original heap leach processed tailings and consists of approximately 165,000 tons (15 percent of the total) at an average depth of two to three feet. Most of the original sand tailings from the old tailings area were reprocessed and discharged into the larger, new tailings pile. The new tailings pile contains approximately 935,000 tons (85 percent of the total) and is the result of the

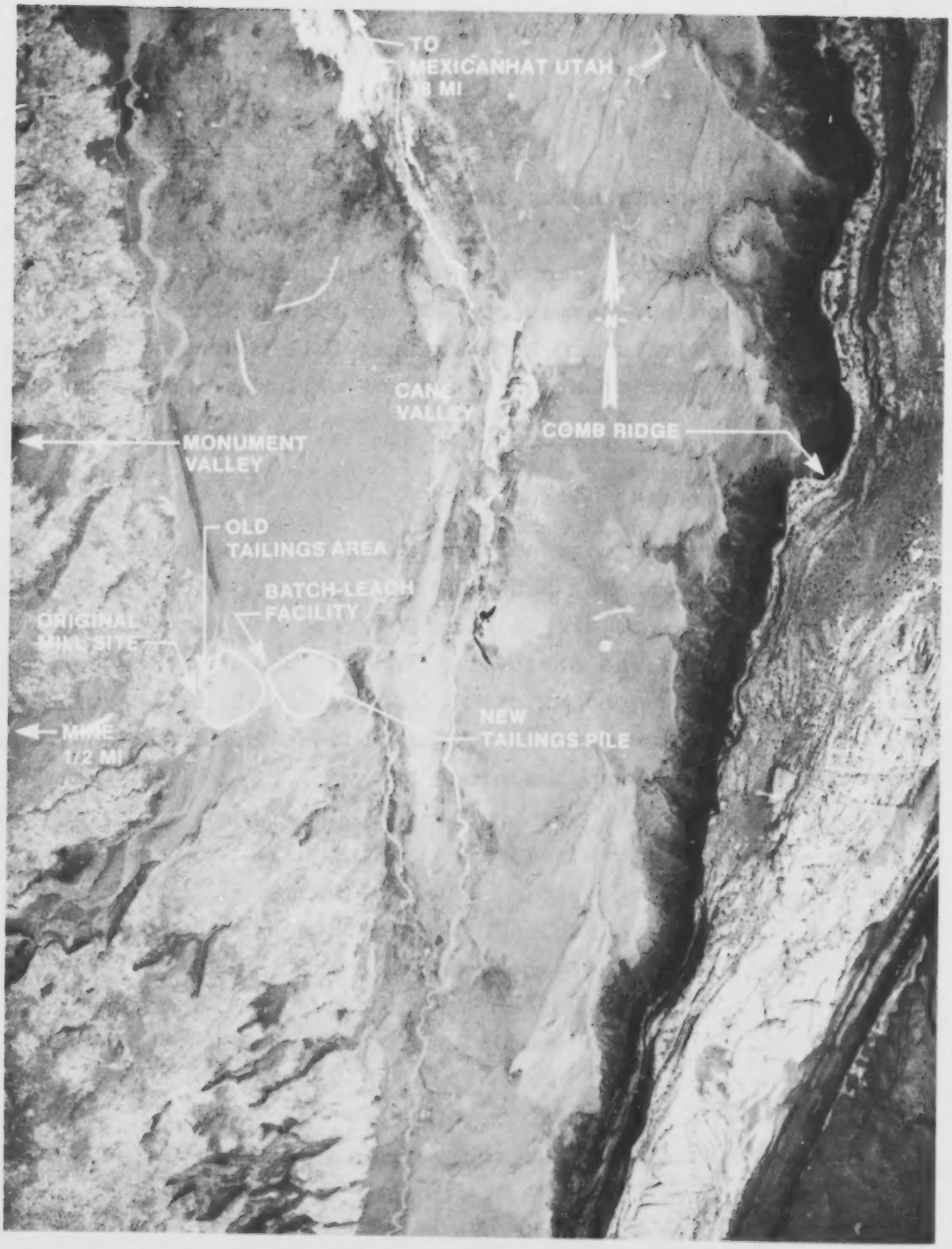

Figure 1. Aerial photograph of former Monument Uranium Mill site area

concentrator process. This pile covers 20 acres, is cone-shaped, and stands 55 feet high (FBDU, 1977).

OWNERSHIP

The mill was originally constructed and operated by the Vanadium Corporation of America, which was later merged into the Foote Mineral Company. The span of construction and operation of the site was from the summer of 1955 to 1968. Since the mill was built on the Navajo Indian Reservation, full control of the site reverted to the Navajo Nation after the mill was shut down and dismantled.

HISTORY OF OPERATIONS

The upgrader and concentrator units were built to treat low-grade ore from the nearby Monument No. 2 mine, which had formerly shipped high-grade ore directly to Colorado for processing. Monument No. 2 mine was discovered in 1943 and produced approximately 0.75 million tons of ore. In addition, over one million tons of low-grade ore were mined for processing in the upgrader, concentrator, or by heap leaching.

The upgrader, a sand-slime operation unit, was the first plant at the site and operated from the summer of 1955 through July 1964. In October 1964, a batch-leaching and concentrator facility was installed at the same site and treated 1.1 million tons of the sand tailings from the previous operation. By November 1967, the final operation, heap-leaching 100,000 tons of low-grade ore, was completed.

In May 1968, a U.S. PHS environmental survey was conducted at the Monument site and results indicated that existing radiation

levels did not exceed former Atomic Energy Commission recommended exposure limits. However, due to diverse weather conditions that may affect the tailings, it was recommended that they be stabilized against wind erosion, or that periodic monitoring be carried out to insure that significant wind erosion would not occur (Snelling, 1969).

A "screening" survey of dwellings in the area was conducted by the Navajo Environmental Protection Commission (NEPC) in February 1975. It was found that uranium mill tailings and ore had been extensively used for construction by the Cane Valley residents. A follow-up survey of all the dwellings and structures in the area was conducted later that year by the EPA and IHS staffs to identify dwellings in which uranium mill tailings had been used and to assess the resulting radiation exposures. This subsequent survey confirmed the findings of the earlier one (Hans and Douglas, 1975).

PRESENT CONDITION OF THE SITE

The plant has been completely dismantled, leaving only concrete foundations, an abandoned shack on the hill at the west end of the site, and various rubble. Some of the building materials and equipment have been buried in the new tailings pile. There are a few dwellings, occupied by four Navajo families, on the east and south sides of the site. Three of these dwellings are very close to the eastern edge of the site, with the closest located 1300 feet northeast. The Navajos use an access road which runs from an old airstrip, past the new tailings pile, and on to their dwellings. Livestock from a corral less than 600 feet away are occasionally seen on the site, including sheep that are grazed in the area. Although the tailings are reasonably resistant to wind erosion, gamma radiation measurements made by EPA in 1974 indicate some wind erosion is occurring. Some water erosion has been observed, and there is evidence of it in the former ore heap leaching area. There has been no attempt to stabilize the tailings.

RADIATION SURVEY

Radiation surveys were conducted at the Monument site from April 8 to April 13, 1974. Due to the non-availability of electrical power in the area, no air sampling was conducted. Radiological surveys around occupied dwellings were also not conducted during this survey period since the principal objective was to determine the extent of the tailings erosion by wind and water.

Two lines were located around the mill site area (Figure 2). One line is labeled 10 μR/hr and the other is labeled "background." These lines are related to exposure rates from wind and water eroded tailings only and are independent of the exposure rate from the tailings piles. These lines indicate that if eroded tailings and ore (exclusive of the tailings piles) were removed from the inside of the lines, the remaining radioactive materials outside of the line would produce an exposure rate approximately equal to that of the line designation. Because of instrument limitations, the background line cut-off was approximately 8 pCi/gm of radium-226, if the radium contaminants were concentrated in the first cm depth of the soil.

Also shown on Figure 2 is the location of the new tailings pile. Measurements made on the pile surface were generally less than 100 μR/hr. Scattered throughout the mill area are piles and pieces of ore which measured up to several hundred μR/hr at contact. Because of this, the 10 μR/hr line enclosed most of the former mill and ore storage area. The background line was not closed to the west of the site because a large portion of the area is exposed bedrock. In addition, the road entering the site from the east and the wash which bisects the site in the south to north direction were also contaminated. Some mill equipment is buried in the south side of the wash.

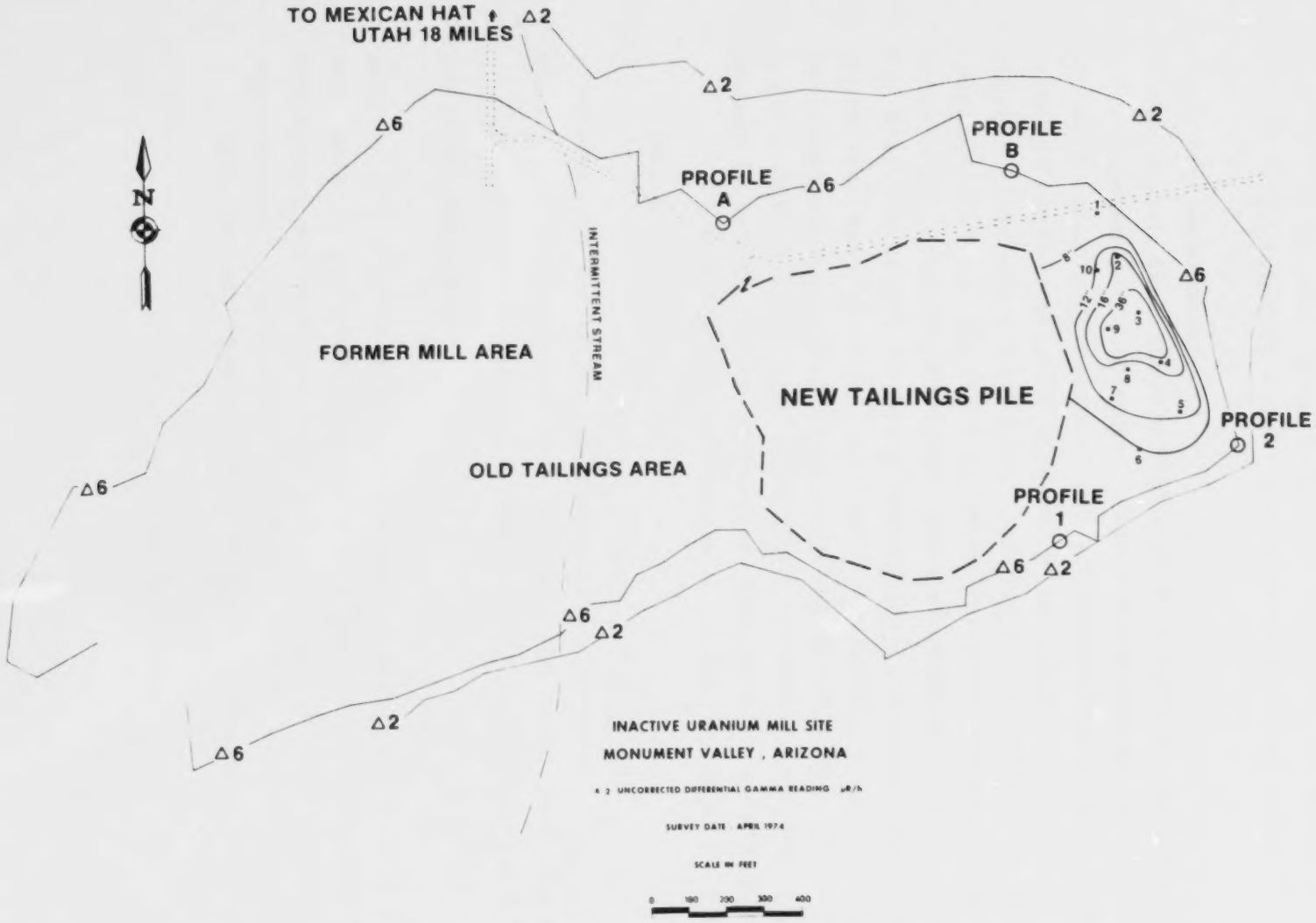

Figure 2. Soil profile locations around the former Monument Uranium Mill site

ANCILLARY DATA AND MEASUREMENTS

Data and measurements not previously published were depth measurements, radionuclide concentrations as a function of depth, background measurements, and radionuclide concentrations in local well water. The techniques used for making the measurements as well as the ensuing data are discussed below.

DEPTH MEASUREMENTS

The depths to which the gamma emitting radionuclides occurred around the site environs were measured two ways. One was by trenching and the other was by bore hole logging.

Trenching

The spread of contaminants around the mill site was measured with a Nuclear Enterprise, NE-148-A, scintillometer with a fabricated shield. The shield was designed such that it could be interposed between the detector and the ground. Two measurements were made with the instrument in contact with the ground: one with the shield in place and the other without the shield in place. The difference between the two measurements (Δ) was indicative of the quantity of gamma emitting radionuclides on the ground. Using this technique, the gamma ray "shine" component from the nearby tailings pile was eliminated. In order to minimize meter fluctuations, the scintillometer's time constant was increased to 10 seconds. Some Δ measurements were made in contamination-free areas around the mill site to establish a Δ value for background.

At selected sites, trenches were dug at 5 cm depth intervals. At each depth interval, including the surface, open-

shield and closed-shield measurements were made. Trenching continued until a depth was reached at which the open shield minus the closed shield measurement was the same as the previously determined background.

When background was reached after successive 5 cm depth intervals, the excavation depth was recorded. Figure 3 indicates locations around the tailings pile where depth measurements were made. The off-pile area was gridded into 100 foot squares and the depth (cm) was recorded in the upper left hand corner of each square. For the most part, the eroded tailings were contained within the first 5 cm depth in areas outside of the 10 μR/hr line. The area on the north or lee side of the tailings pile had tailings to a depth of 30 cm, which was due primarily to wind erosion. The area inside and adjacent to the 10 μR/hr line on the east side of the pile was diked. The dike was presumed to have been built to catch process fluids from heap leaching. Tailings and leached materials were found to depths of 100 cm in this area. Very few depth measurements were made on the north and west sides of the tailings pile because bedrock was exposed in a large portion of these areas.

Wind erosion of the sand tailings at this site was not as extensive as other Navajo Reservation sites surveyed. This is probably because the fine portion (slimes) of mill tailings was hauled away for further processing.

Bore Hole Logging

In order to explore the diked area previously mentioned, a truck-mounted auger was used to drill 10 bore holes. Their locations are shown in Figure 4. The bore holes were logged with a gamma ray scintillation probe assembly containing a 2.54 cm by 1.27 cm diameter sodium iodide crystal. The assembly was shielded with 1.27 cm of lead on the sides and bottom, with an 0.64 cm wide 360° port at the crystal midline. A bore hole log for each

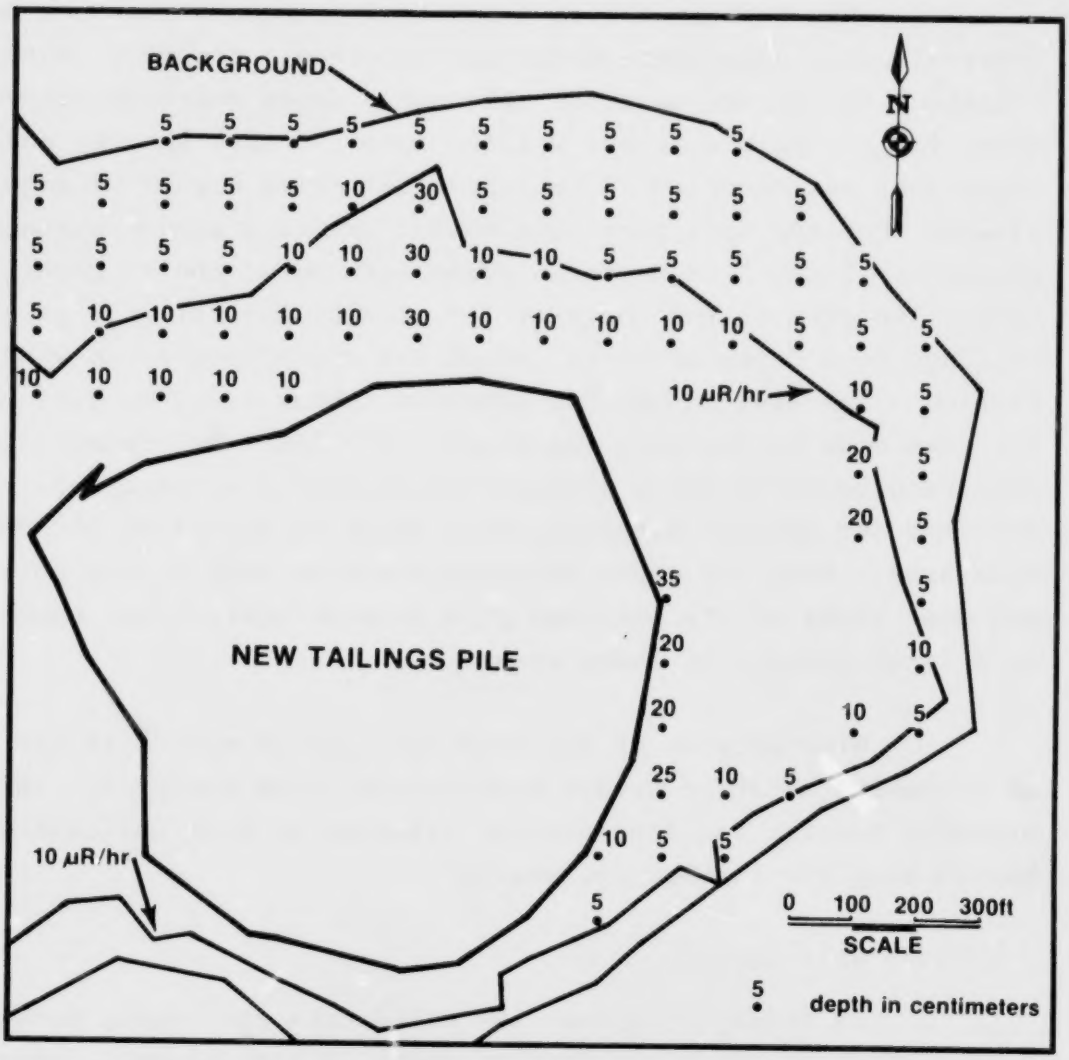

Figure 3. Trench locations and depth of contaminants around the Monument tailings area

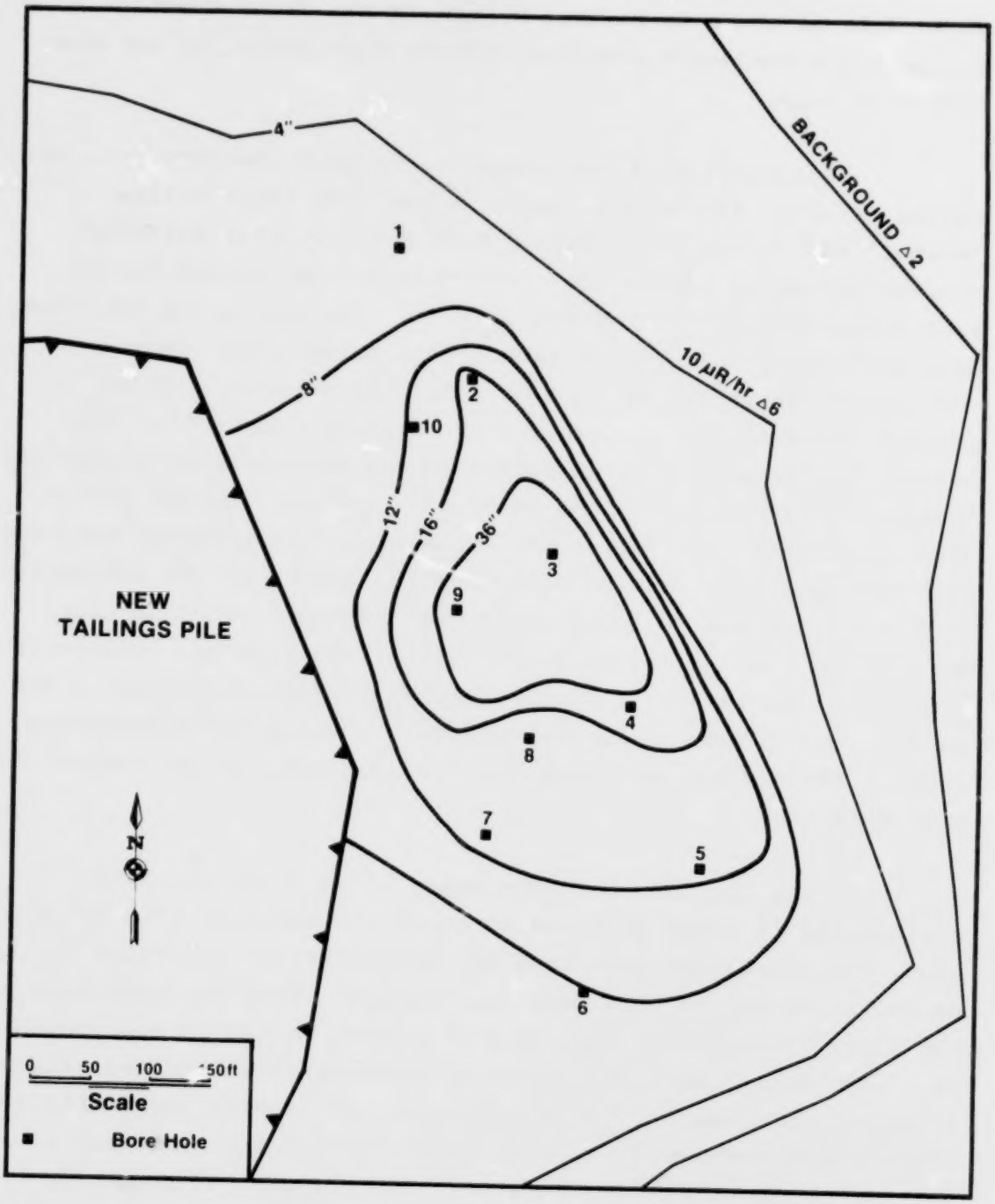

Figure 4. Bore hole locations and depth profiles in diked area

auger hole is shown in Figures 5 through 14. Also shown in Figure 4 are the depth profiles derived from trenching and from bore hole logs.

Calibration of the logging equipment was done in a 55-gallon oil drum filled with sand. A one-inch thick hollow "washer" was filled with uranium mill tailings with different concentrations of radium-226. The "washer" was placed in the sand filled barrel to obtain a detector response to the tailings. This provided a calibration factor ("mR/hr-relative" versus radium-226 concentration (pCi/gm)) for the detector. After passing the detector through the calibration "washer" in the barrel, the "exposure rate" decreased exponentially to background levels. This was due to the combined shielding effects of the lead shield and sand fill. The exponential relationship was used with the bore hole logs to determine the depths of the contaminants (i.e., the log was followed until the "exposure rate" decrease matched the exponential decrease established with the calibration barrel). The estimated average radium-226 concentration in the bore holes was made using the calibration curve for the logging probe. Adjustments were made for the thickness of the radium-226 contamination.

The log for each hole began 10 cm above the hole surface and is noted as minus 10 cm on the vertical axis of the logs. The subsurface locations of radium-226 are indicated by the dashed lines on the bore hole log figures. With the exception of the first 20-cm depth, bore hole 1 (Figure 5) can be considered as a background log. The average "exposure rate" for the background portion was 0.15 mR/hr-relative. Bore hole log 2 (Figure 6) indicated radium-226 to a depth of 40 cm below grade and an average radium-226 concentration of 950 pCi/gm. Although the surface was contaminated, most of the contamination was located at about 20 cm below grade.

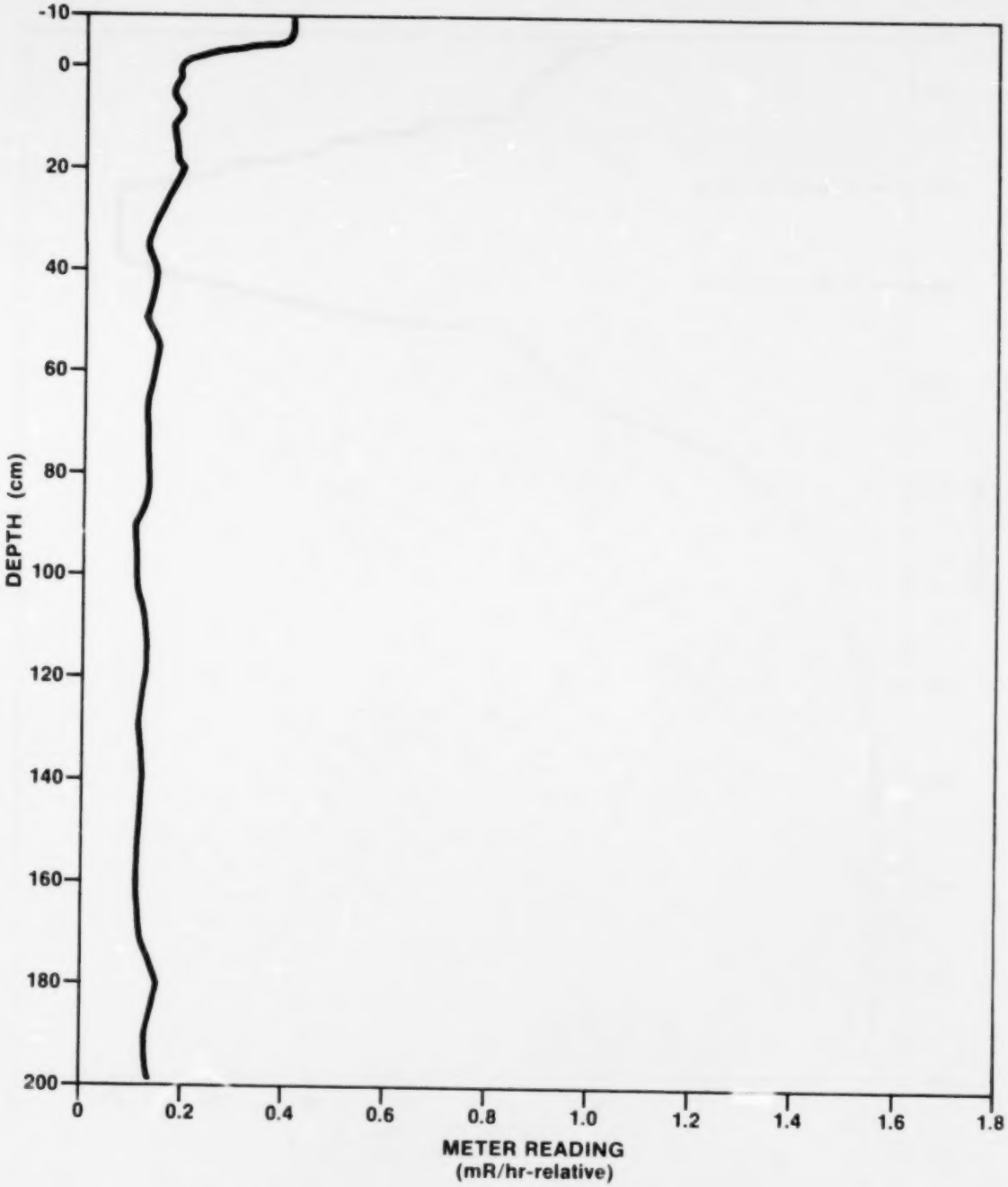

Figure 5. Bore hole log 1

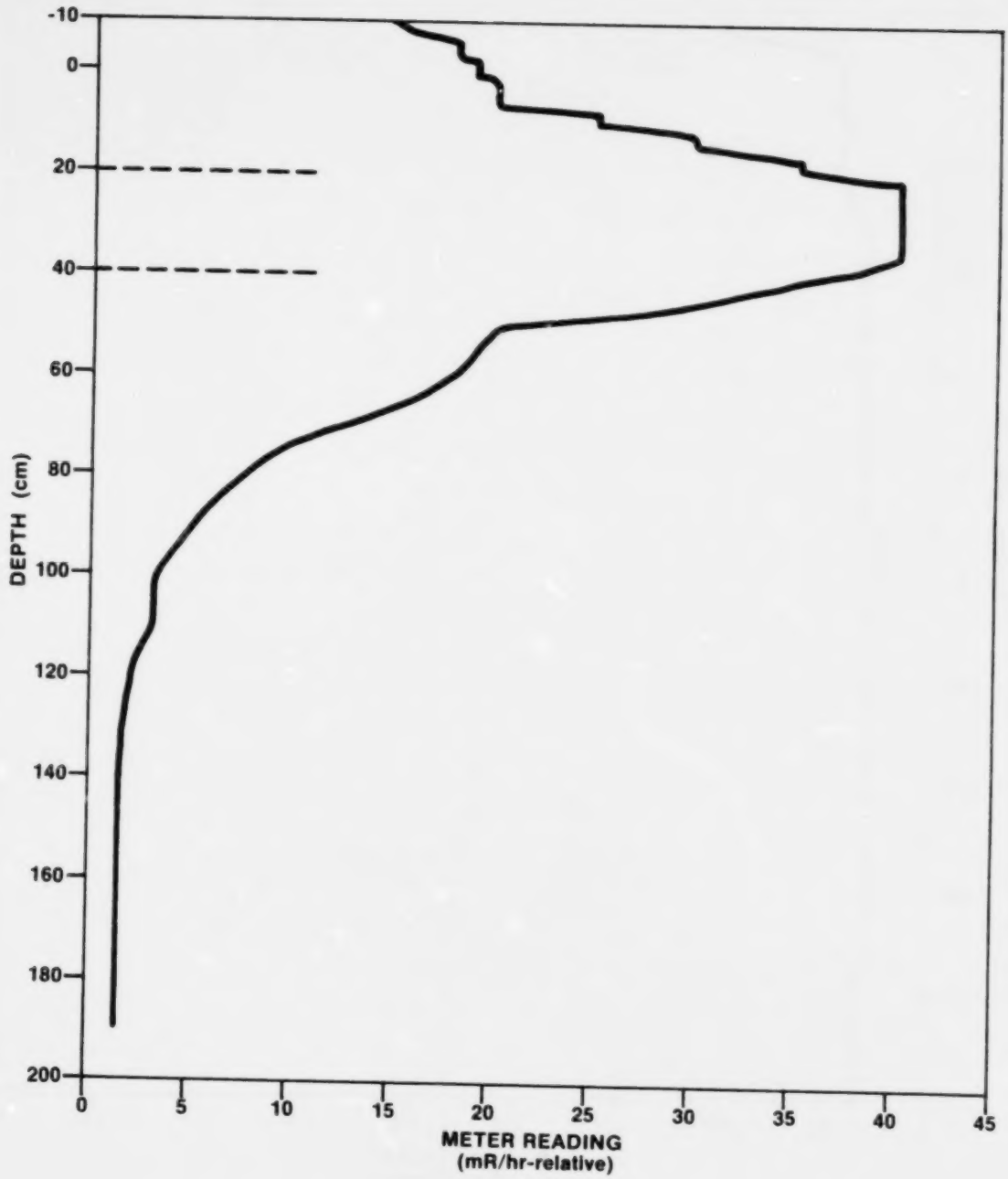

Figure 6. Bore hole log 2

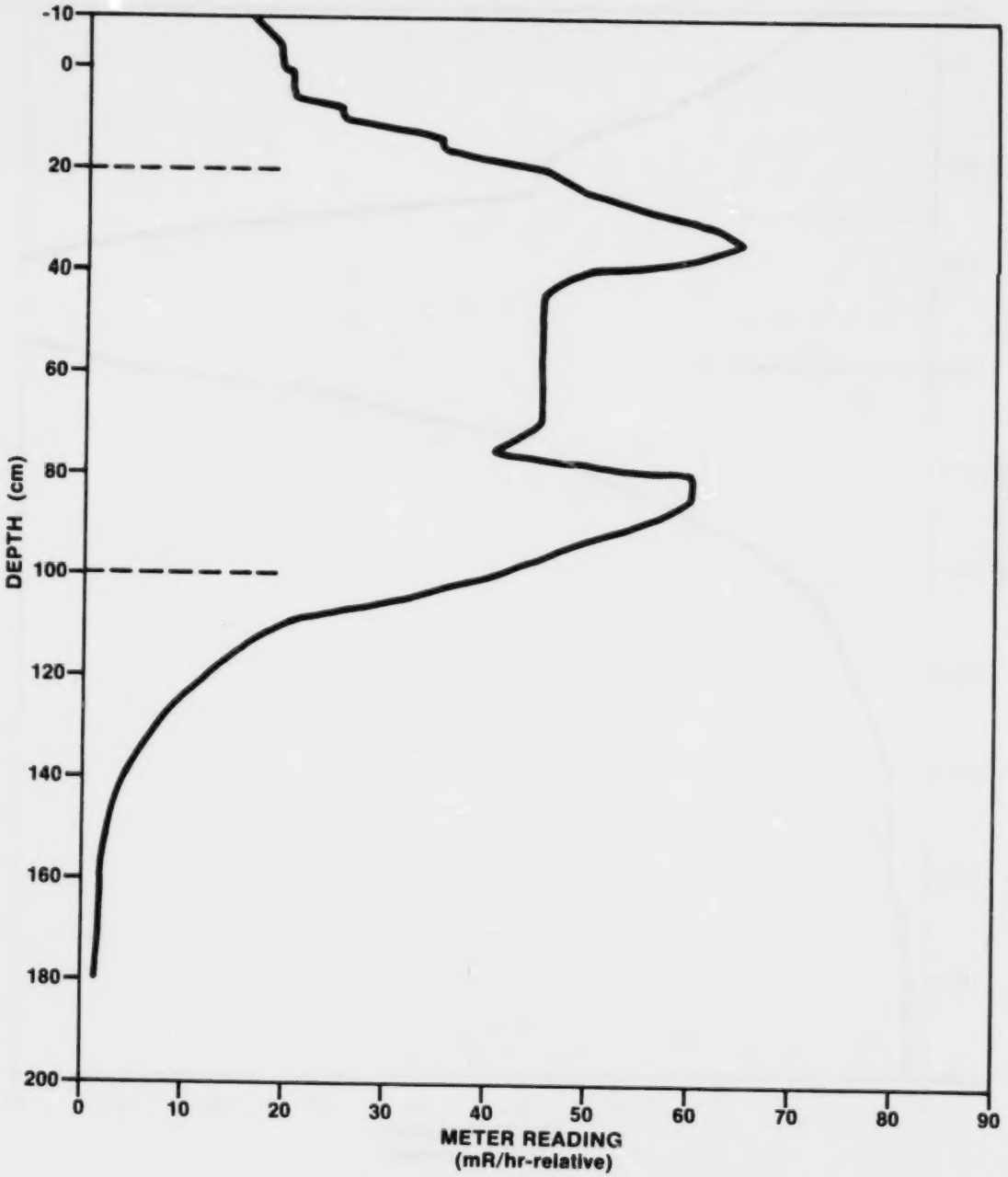

Figure 7. Bore hole log 3

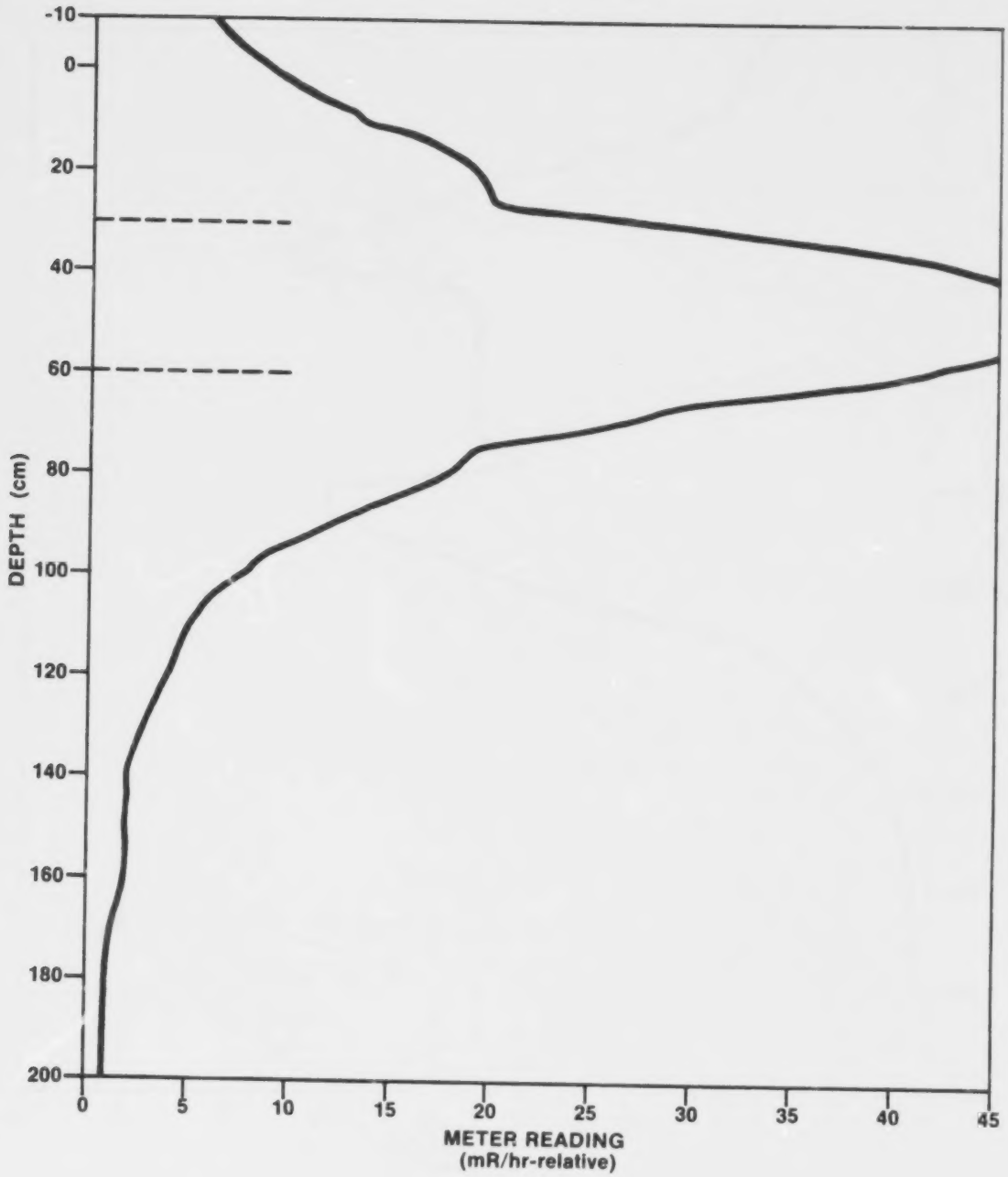

Figure 8. Bore hole log 4

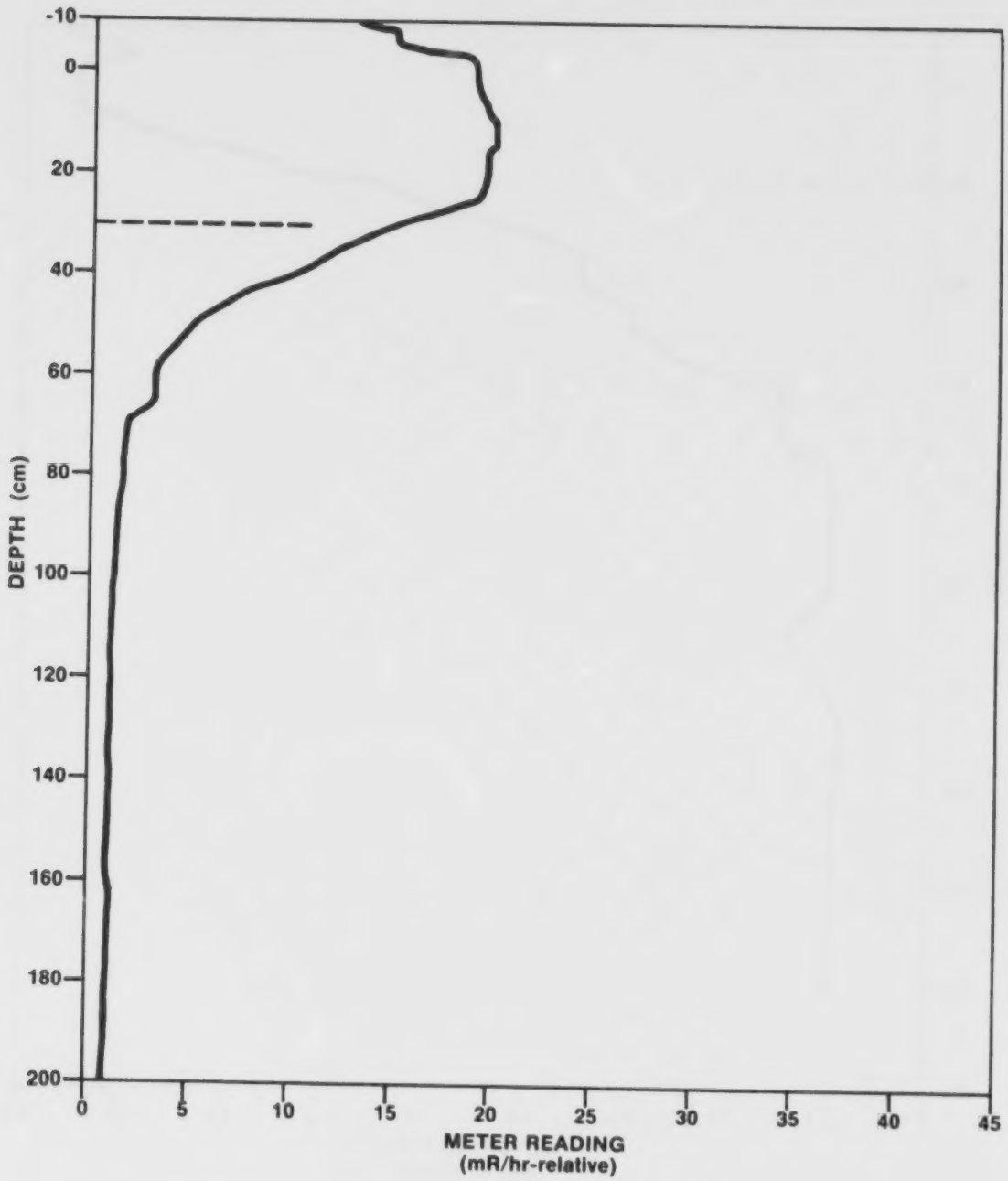

Figure 9. Bore hole log 5

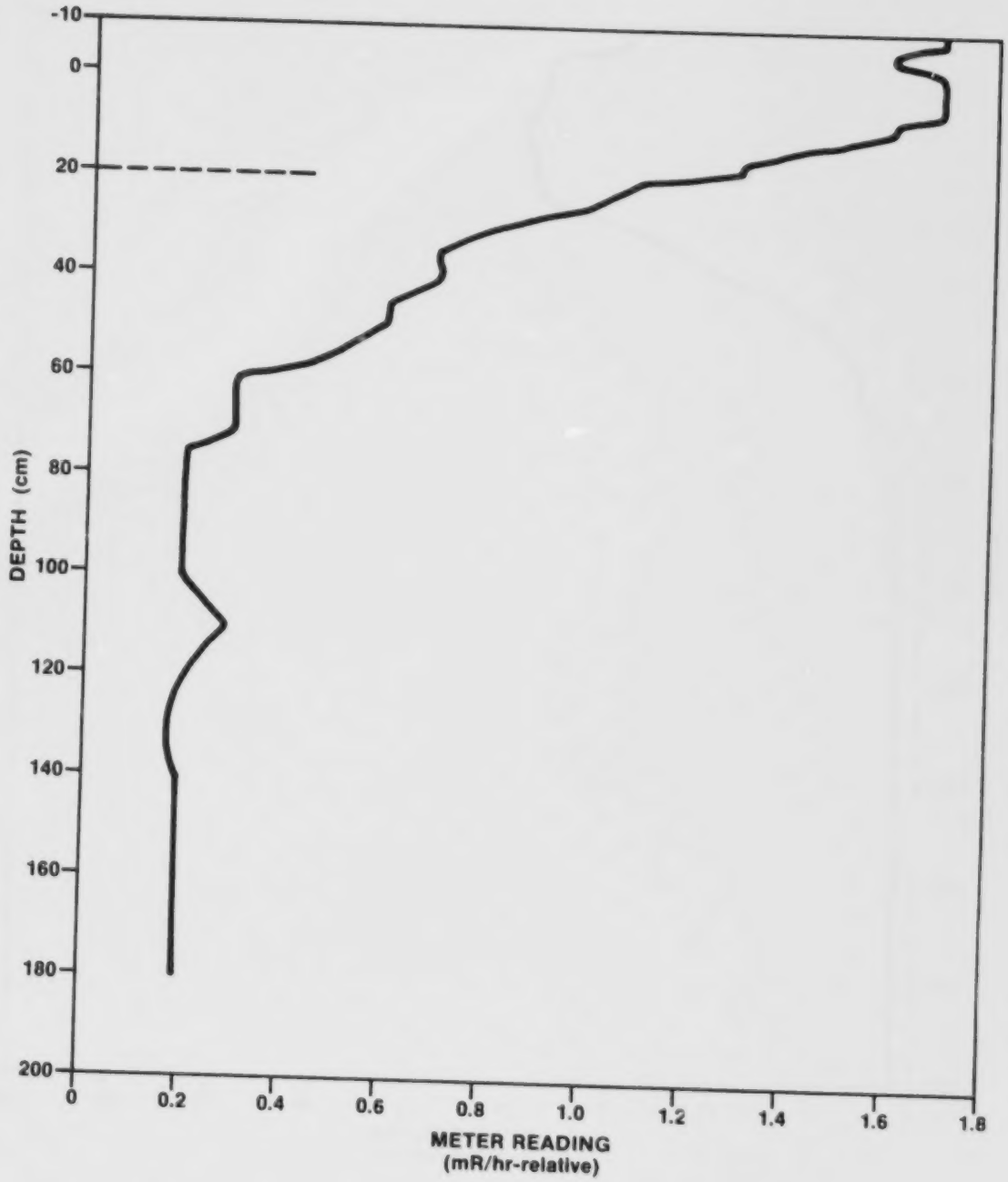

Figure 10. Bore hole log 6

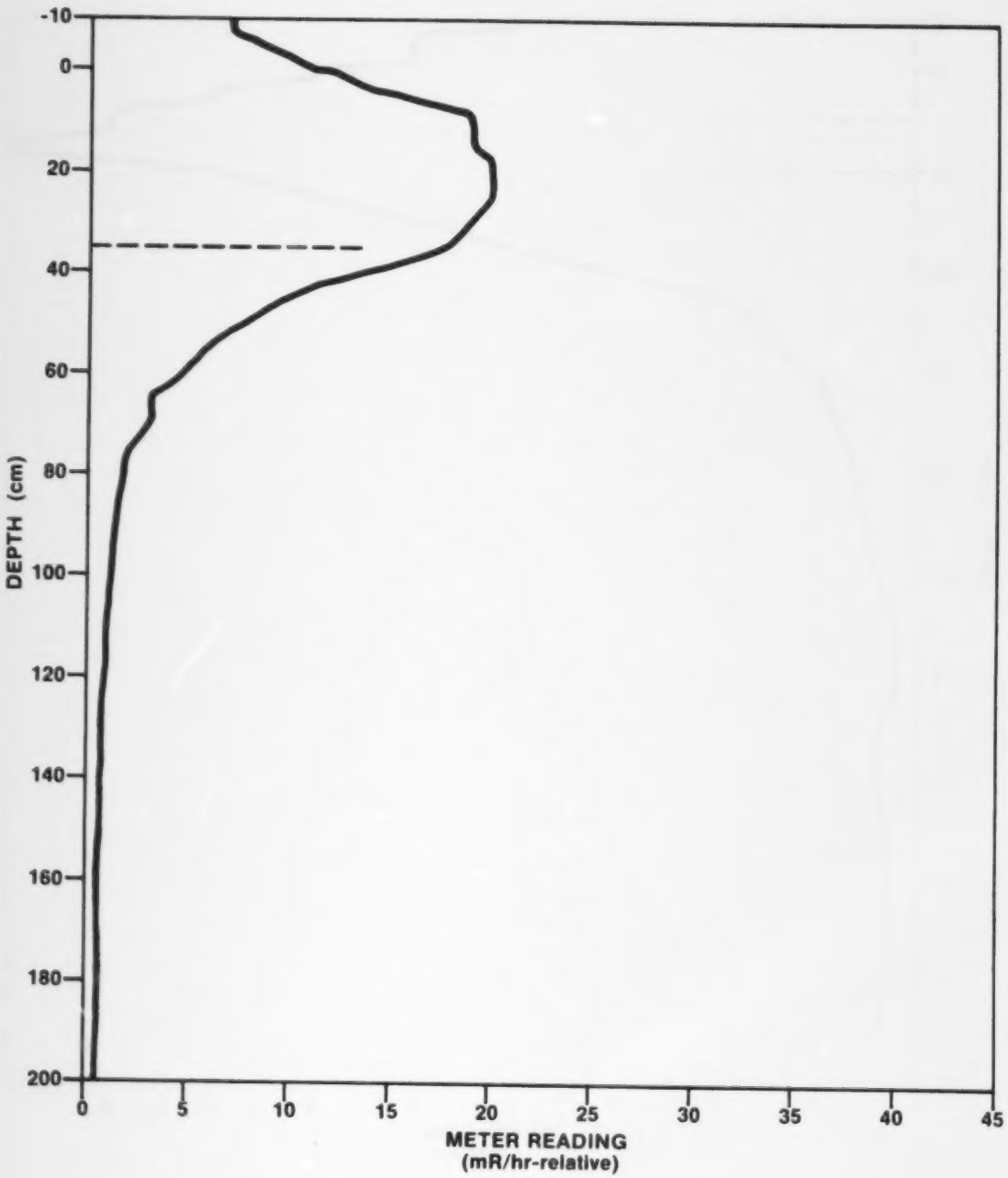

Figure 11. Bore hole log 7

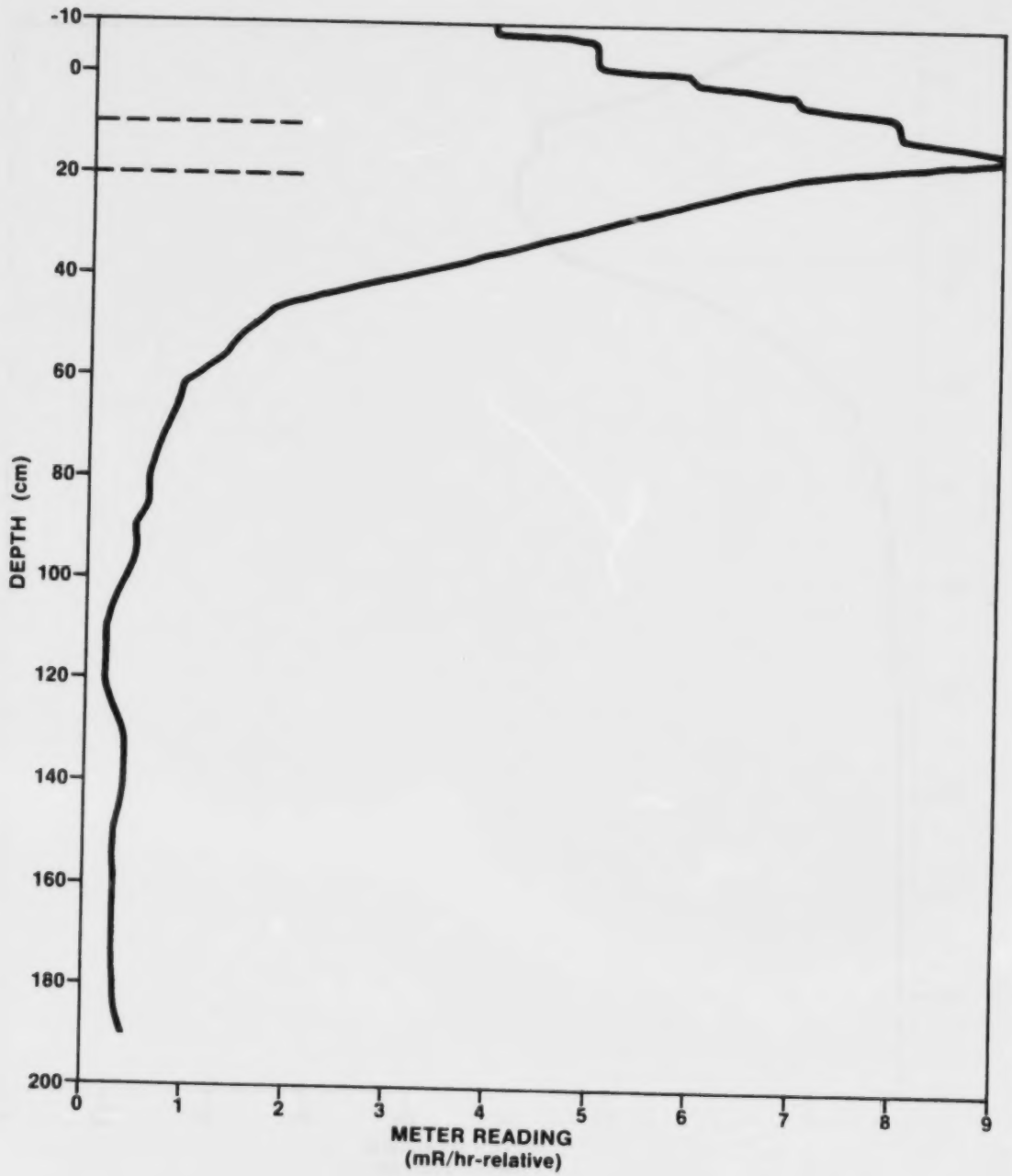

Figure 12. Bore hole log 8

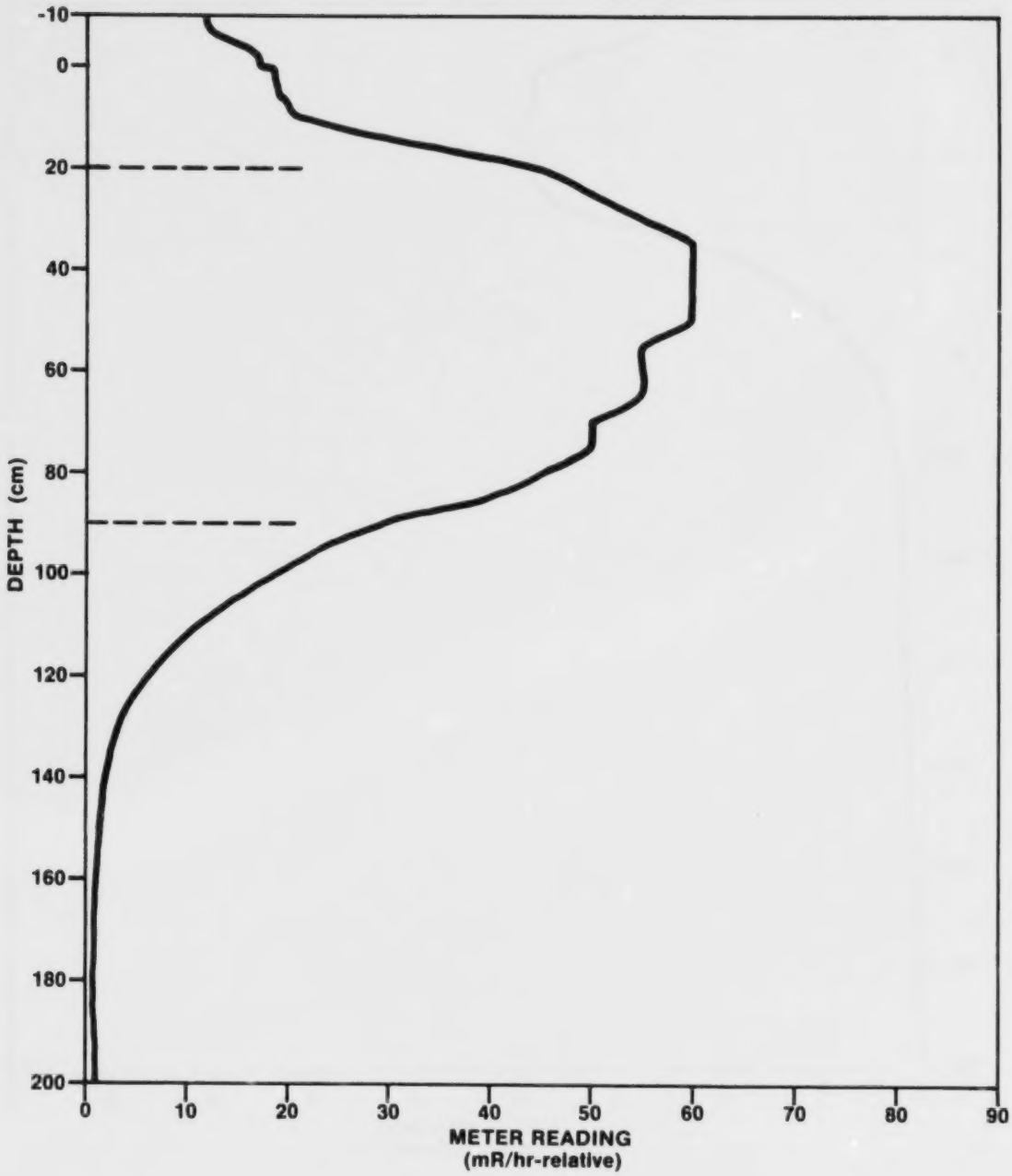

Figure 13. Bore hole log 9

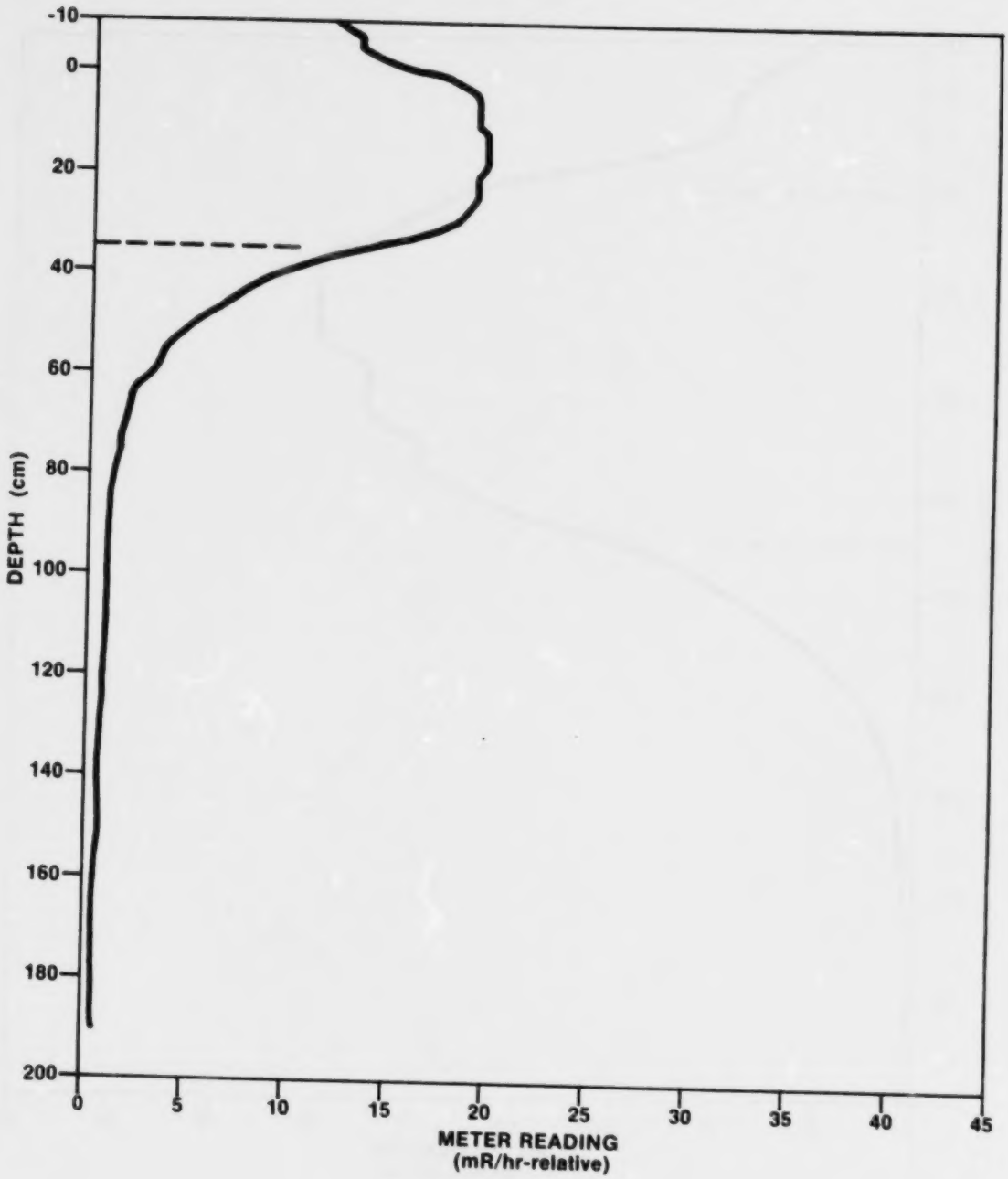

Figure 14. Bore hole log 10

Bore hole log 3 (Figure 7) indicates two distinct peaks below grade occurring at about 35 and 85 cm below grade. The average radium-226 concentration was 750 pCi/gm and the depth of the contaminants is estimated to extend to about 100 cm below grade.

Bore hole log 4 (Figure 8) indicates surface contamination which increases and peaks at approximately 50 cm below grade. The depth of the contaminants was 60 cm and the average radium-226 concentration was 130 pCi/gm.

Bore hole log 5 (Figure 9) indicates surface contamination extending to a depth of 30 cm. The average radium-226 concentration is estimated to be 260 pCi/gm.

Bore hole log 6 (Figure 10) indicates surface contamination to a depth of 20 cm and an average radium-226 concentration of 15 pCi/gm.

Bore hole log 7 (Figure 11) is indicative of sub-surface contamination to a depth of 35 cm below grade having an average radium-226 concentration of 280 pCi/gm.

Bore hole log 8 (Figure 12) indicates contamination to a depth of 20 cm and a concentration of 460 pCi/gm.

Bore hole log 9 (Figure 13) indicates sub-surface contamination, most of which lies between 20 and 90 cm below grade. The average radium-226 concentration is relatively high at 800 pCi/gm.

Bore hole log 10 (Figure 14) indicates surface contamination down to a depth of 35 cm below grade having an average concentration of 240 pCi/gm.

ESTIMATES OF THE RADIUM-226 AND URANIUM CONTENT IN DIKED AREA

The radioactive contents of the diked area were originally presumed to have resulted from drainage from the new tailings pile. Further checking, however, indicated that the materials in the diked area may have come from the batch-leach process (Haldane, 1978). Apparently, this process was never very successful because the batch tanks frequently became plugged due to the high clay content of the ore and the contents of the tanks were dumped in the diked area. Since no uranium separation occurred at the mill, the uranium should be in radioactive equilibrium with the radium-226 content of the diked area. A surface sample was taken from the "hotter" area of the diked area and the radiochemical analysis indicated a radium-226 concentration of 1300 pCi/gm. Unfortunately, the uranium analysis for this sample was lost. The total volume of the leach losses in the diked area is:

length - 650 feet
width - 250 feet
average depth - 1.5 feet
volume (ft^3) = 2.4×10^5 ft^3

The estimated average concentration of radium-226, based on the bore hole logs is:

Log Number	Average Concentration (pCi/gm)	Adjusted Average Concentration (pCi/gm)*
1	1.5	1.5
2	950	450.0
3	750	542.0
4	130	65.0
5	260	260.0
6	15	15.0
7	280	280.0
8	460	230.0
9	800	620.0
10	240	240.0
	Σ = 3886	Σ = 2703

*The adjusted average radium concentration is the average concentration between the ground surface and the maximum depth at which the radium was detected (i.e., below-grade radium concentrations were averaged to the surface).

Adjusted average radium-226 concentration $\sim$ 300 pCi/gm

Total weight of leach losses:

Weight (gm) $= (2.4 \times 10^5 ft^3)\ (2.88 \times 10^4 cm^3/ft^3)\ (1.6 gm/cm^3) = 1.1 \times 10^{10} gm$

Total radium-226 content of impoundment:

Radium-226 (Ci) $= 1.1 \times 10^{10} gm \times 300\ pCi/gm = 3.3 \times 10^{12} pCi$ or 3.3 Ci

Assuming that uranium-238 is in equilibrium with the radium-226, the weight of uranium-238 in the impoundment is:

Weight of Uranium-238
in the diked area $\sim$ 3.3 Ci(uranium-238) $\times (3 \times 10^6 gm/Ci)$
$\sim 9.9 \times 10^6 gm \sim$ 22,000 lbs.

No bore holes were drilled in the old tailings area. Some additional uranium may be present in this area from heap-leach losses.

SOIL PROFILES

Four off-pile profile trenches were dug along the 10μR/hr line in order to examine the radionuclide distribution as a function of depth (Figure 2). The profile samples were obtained by digging a trench and sampling from the side of the exposed trench wall. The sampling intervals were 5 cm and all soil collected in the interval was mixed and portioned into aliquots for radiochemical analysis.

Samples were collected to a depth of 20 cm in profile A and the radionuclide concentration versus depth is indicated on Figure 15. The radium-226 concentrations dropped by a factor of nearly 10 from the 0-5 cm depth to the 5-10 cm depth and rose back to nearly the original surface concentration at a depth of 15-20 cm. The uranium concentrations exhibited a reduction of

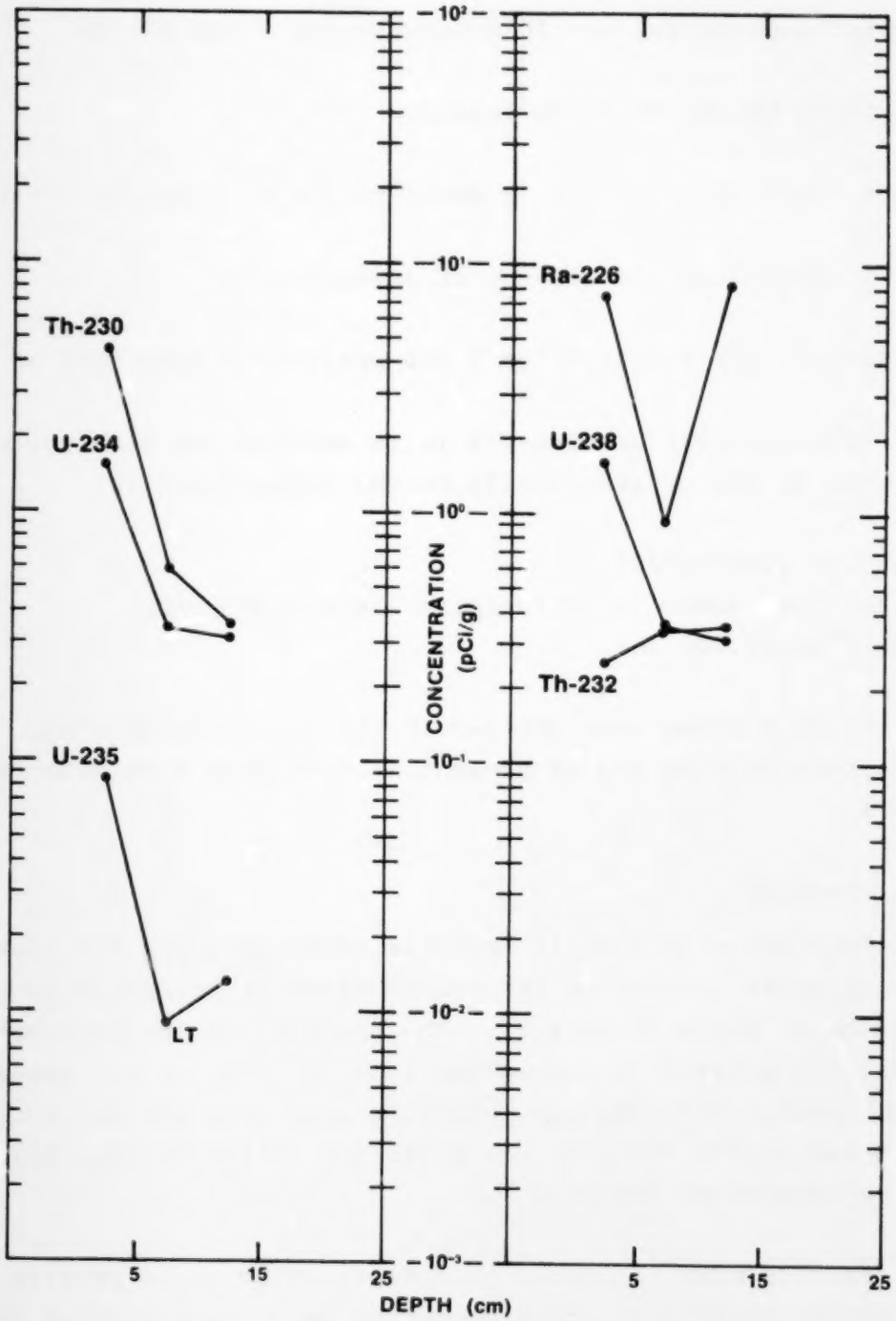

Figure 15. Soil profile A - Radionuclide concentration versus depth

approximately 76 percent between the 0-5 and 5-10 cm depths and essentially remained constant at the 10-15 cm depth. Thorium-230 decreased at approximately the same rate as the uranium. Very little thorium-232 was present in the tailings as it was relatively constant with depth. The apparent ratios of the concentration of radium to uranium indicates that the contaminants were heap leached sand tailings.

Figure 16 depicts the decrease of the listed radionuclides as a function of depth at profile B location. The surface concentrations of the uraniums, radium and thorium-230 are more closely in equilibrium than those in profile A. This seems to indicate that some ore or slimes were the principal contaminants. It is possible that some seepage from the tailings pile or the batch leach area occurred at this location.

The uranium and thorium-230 concentrations in profile 1 follow each other closely as a function of depth (Figure 17). The radium-226 concentrations, however, increase sharply at the 15-20 cm depth and return to less than 1 pCi/gm at the 20-25 cm depth. Thorium-232 exhibits a relatively constant concentration between the surface and 25 cm depth. The ratio of the radium concentration to the thorium-230 and uranium concentrations seems to indicate that the contamination, for the most part, is dominated by slimes.

Profile 2 was made outside of the diked area previously discussed (Figure 18). The uranium-238 and uranium-234 concentrations increase abruptly from the 0 to 25 cm depth and then decrease. The radium-226 concentrations generally follow the uranium concentrations as a function of depth, but are a factor of approximately 30 lower. Thorium-230 concentrations increase from 0 to 15 cm and then decrease very rapidly to the 35 cm depth. Since the profile was made outside but adjacent to the dike, it probably represents dike seepage. Since uranium is generally more soluble than radium, it would be expected to

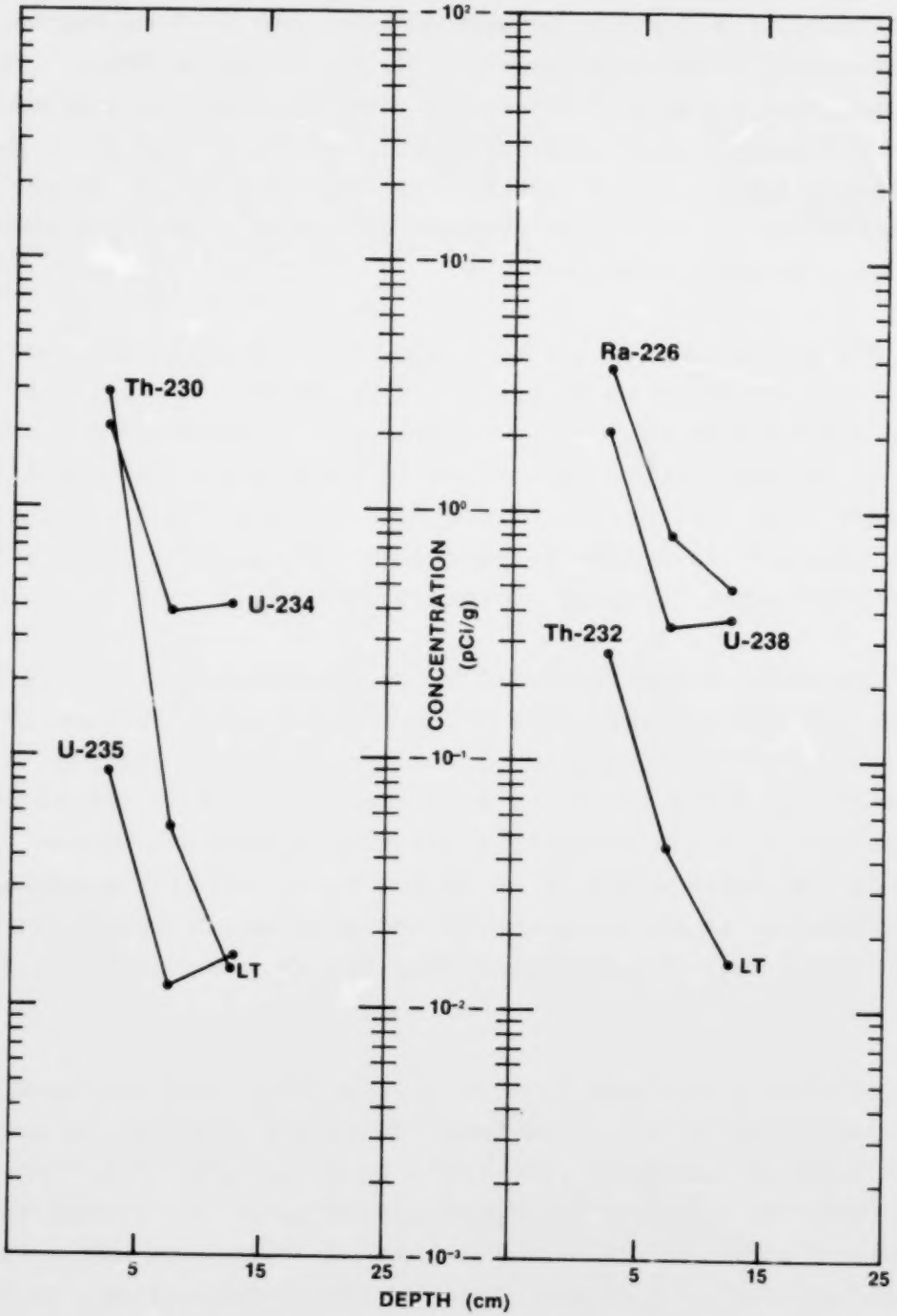

Figure 16. Soil profile B - Radionuclide concentration versus depth

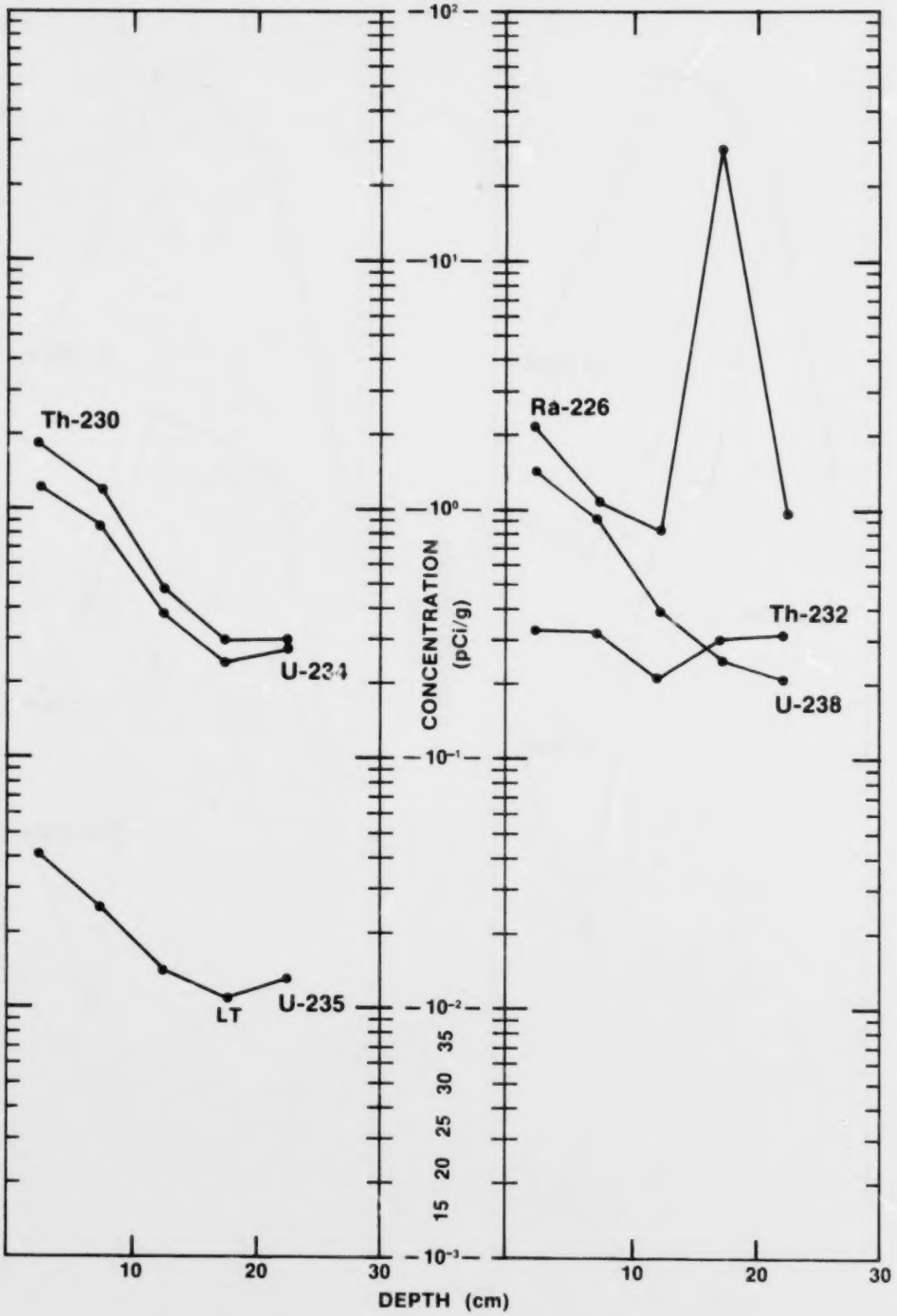

Figure 17. Soil profile 1 - Radionuclide concentration versus depth

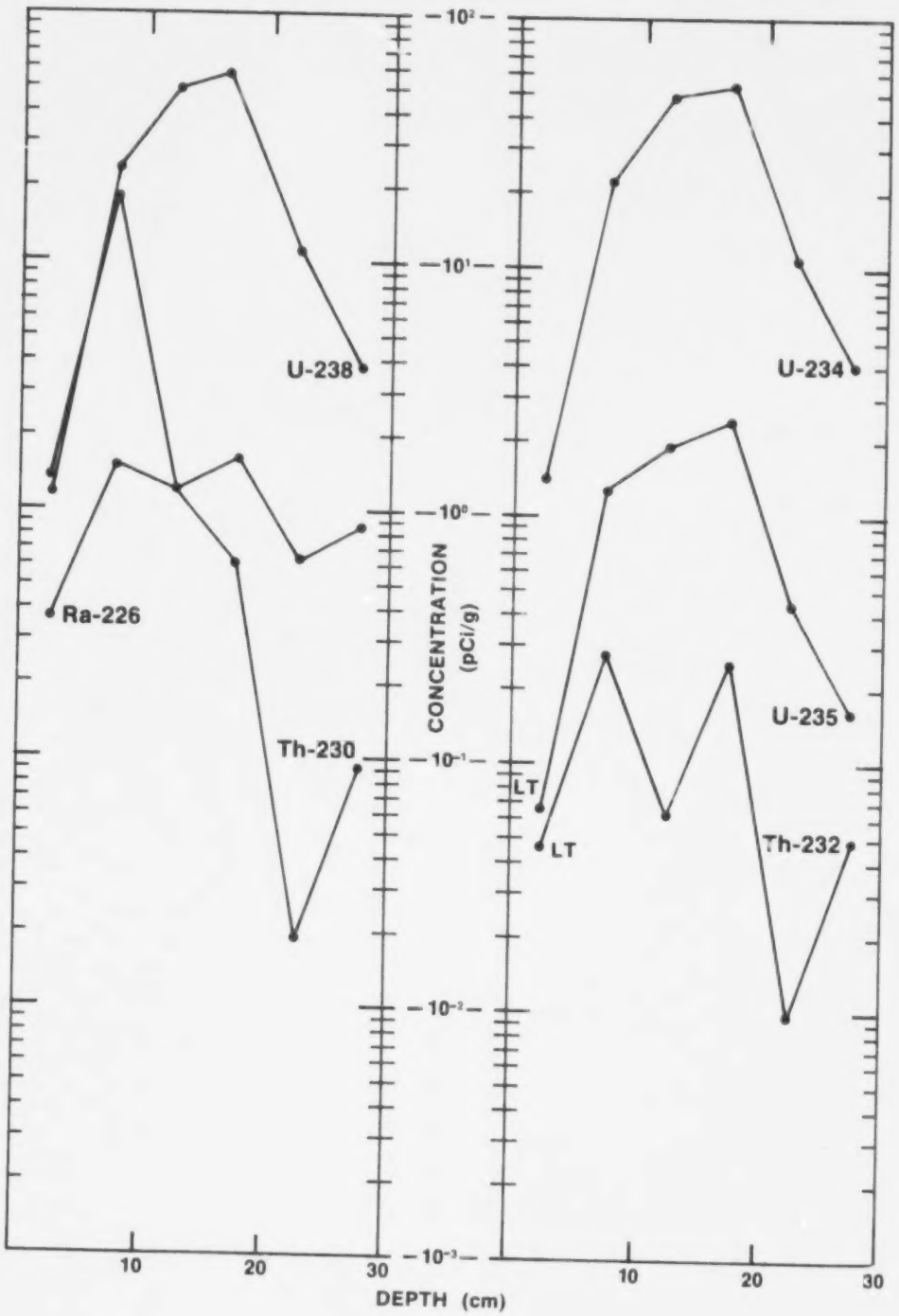

Figure 18. Soil profile 2 - Radionuclide concentration versus depth

penetrate the dike more readily. It appears that the thorium-230 was either held up more readily in the diked area or that it was more soluble than the uranium and was diluted and carried to greater depths than those sampled.

The radionuclide concentrations and their two sigma counting errors are listed in Table 1.

ENVIRONMENTAL GAMMA RAY EXPOSURE MEASUREMENTS

Gamma ray exposure rate measurements were made around the vicinity of the tailings piles during surveys of dwellings in Cane Valley, Arizona (Hans and Douglas, 1975). The measurements were made with a Reuter-Stokes RS-111 pressurized ion chamber (PIC) at three feet above the ground. Although the average gamma ray exposure rate was reported (Hans and Douglas, 1975), the individual exposure rates were not reported. Figure 19 indicates the locations where the gamma ray exposure rates were made. Table 2 lists the measurement values.

The exposure rate at location B2 is probably anomalous because it was made near the airstrip which had some scattered ore or tailings use. Location B9 was probably somewhat elevated because of its proximity to the tailings pile.

GROUND-WATER SAMPLING

Several drinking water wells were sampled during the surveys of the Cane Valley residential locations (Hans and Douglas, 1975). Only the radium-226 concentrations were available at the time of the previous report preparation. Radium-226 concentrations in well water as well as other radionuclide concentrations are listed in Table 3. The well locations are shown in Figure 20.

The radium-226 concentration exceeded 1 pCi/l in only one well (well 1). Thorium concentrations were generally below 0.1 pCi/l, with the exception of well 3. The highest uranium-238 concentration observed was 6.1 pCi/l in well 4. This is approximately 18 µg/l.

TABLE 1. CONCENTRATION OF RADIONUCLIDES IN SOIL PROFILES

Profile	Depth (cm)	Radionuclide	Concentration ± Two-Sigma Counting Error (pCi/gm)
1	0-5	Ra-226	2.2 ± .28
	5-10		1.1 ± .20
	10-15		.82 ± .17
	15-20		.29 ± .99
	20-25		.96 ± .19
1	0-5	U-234	1.2 ± .13
	5-10		.85 ± .11
	10-15		.37 ± .06
	15-20		.24 ± .055
	20-25		.26 ± .051
1	0-5	U-235	.04 ± .02
	5-10		.025 ± .017
	10-15		.014 ± .012
	15-20		LT.011 ± -
	20-25		.013 ± .012
1	0-5	U-238	1.4 ± .14
	5-10		.91 ± .11
	10-15		.39 ± .061
	15-20		.25 ± .056
	20-25		.21 ± .046
1	0-5	Th-230	1.8 ± .13
	5-10		1.2 ± .10
	10-15		.47 ± .065
	15-20		.29 ± .053
	20-25		.29 ± .050
1	0-5	Th-232	.33 ± .056
	5-10		.33 ± .054
	10-15		.21 ± .043
	15-20		.30 ± .053
	20-25		.31 ± .051
2	0-5	Ra-226	36. ± 1.1
	5-10		1.5 ± .23
	10-15		1.2 ± .20
	15-20		1.6 ± .24
	20-25		.62 ± .15
	25-30		.86 ± .17

LT = Less than the minimum detectable activity

TABLE 1. CONCENTRATION OF RADIONUCLIDES IN SOIL PROFILES
(Continued)

Profile	Depth (cm)	Radionuclide	Concentration ± Two-Sigma Counting Error (pCi/gm)
2	0-5	U-234	1.4 ± .32
	5-10		23. ± 1.5
	10-15		49. ± 2.8
	15-20		53. ± 4.3
	20-25		11. ± .80
	25-30		4. ± .31
2	0-5	U-235	LT.065 ± -
	5-10		1.3 ± .14
	10-15		1.9 ± .15
	15-20		2.4 ± .26
	20-25		.43 ± .067
	25-30		.16 ± .038
2	0-5	U-238	1.2 ± .29
	5-10		23. ± 1.5
	10-15		49. ± 2.8
	15-20		56. ± 4.6
	20-25		11. ± .77
	25-30		3.8 ± .30
2	0-5	Th-230	1.3 ± .35
	5-10		18. ± .40
	10-15		1.2 ± .15
	15-20		.61 ± .072
	20-25		.019 ± .013
	25-30		.092 ± .029
2	0-5	Th-232	LT.045 ± -
	5-10		.27 ± .048
	10-15		.062 ± .045
	15-20		.25 ± .046
	20-25		.0094 ± .0094
	25-30		.049 ± .022
A	0-5	Ra-226	6.4 ± .47
	5-10		.91 ± .18
	10-15		7.2 ± .49
A	0-5	U-234	1.5 ± .15
	5-10		.33 ± .058
	10-15		.30 ± .055

LT = Less than the minimum detectable activity

TABLE 1. CONCENTRATION OF RADIONUCLIDES IN SOIL PROFILES
(Continued)

Profile	Depth (cm)	Radionuclide	Concentration ± Two-Sigma Counting Error (pCi/gm)
A	0-5	U-235	.083 ± .027
	5-10		LT.0087 ± -
	10-15		.013 ± .012
A	0-5	U-238	1.6 ± .16
	5-10		.35 ± .059
	10-15		.31 ± .057
A	0-5	Th-230	4.4 ± .20
	5-10		.57 ± .074
	10-15		.34 ± .054
A	0-5	Th-232	.25 ± .047
	5-10		.34 ± .056
	10-15		.35 ± .055
B	0-5	Ra-226	3.7 ± .36
	5-10		.79 ± .17
	10-15		.48 ± .13
B	0-5	U-234	2.1 ± .18
	5-10		.38 ± .06
	10-15		.40 ± .063
B	0-5	U-235	.086 ± .028
	5-10		.012 ± .011
	10-15		.016 ± .013
B	0-5	U-238	2.1 ± .18
	5-10		.34 ± .057
	10-15		.37 ± .06
B	0-5	Th-230	2.9 ± .16
	5-10		.051 ± .024
	10-15		LT.014 ± -
B	0-5	Th-232	.27 ± .049
	5-10		.044 ± .002
	10-15		LT.015 ± -

LT = Less than the minimum detectable activity

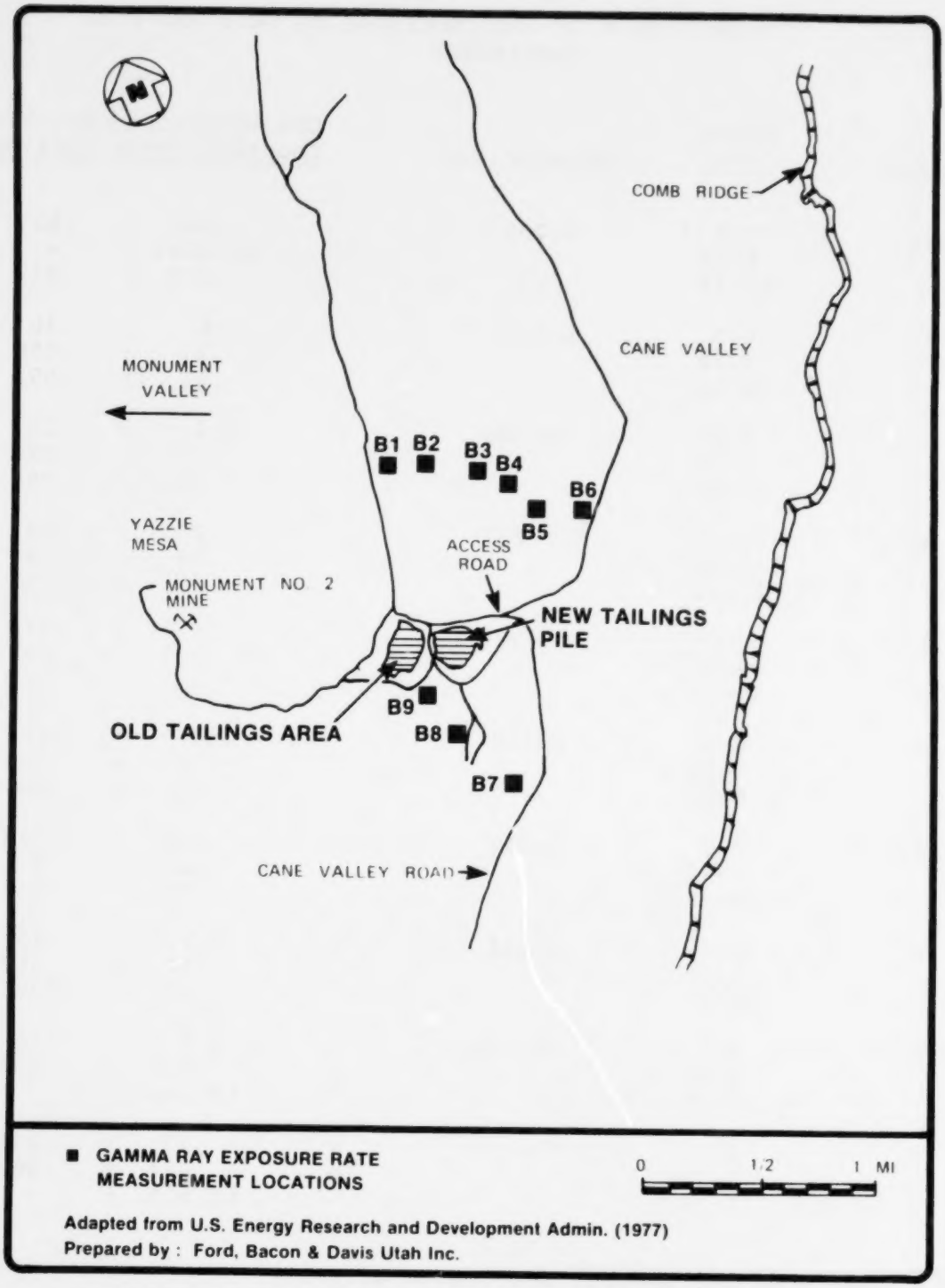

Figure 19. Gamma ray exposure rate measurement locations

TABLE 2. GAMMA RAY EXPOSURE RATES AROUND THE FORMER MONUMENT URANIUM MILL SITE

Location	Gamma Exposure Rate (μR/hr) Low	High	Average
B1	9	11	10
B2	17	20	18.5
B3	7	9	8
B4	8	10	9
B5	8	10	9
B6	8	10	9
B7	9	11	10
B8	9	10	9.5
B9	10	12	11

TABLE 3. TOTAL (SUSPENDED AND DISSOLVED) RADIONUCLIDE CONCENTRATIONS IN WELL WATER NEAR THE FORMER MONUMENT URANIUM MILL SITE

Well No.	Concentration (pCi/l) Uranium-234	Radium-226	Thorium-230	Uranium-238	Thorium-232
1	LT 0.22	1.6 ± .19	LT 0.024	LT 0.15	LT 0.011
2	NA	0.15±0.057	LT 0.038	NA	LT 0.030
3	1.2±0.54	0.11±0.049	0.14 ±0.048	0.69±0.38	0.13±0.046
4	9.0±0.7	0.11±0.056	LT 0.015	6.1 ±0.49	LT 0.015
5	9.9±5.2	0.25±0.082	0.033±0.024	4.3 ±2.4	LT 0.02

Notes: LT means less than the minimum detectable activity
Two-sigma counting error noted when available
NA means no analysis

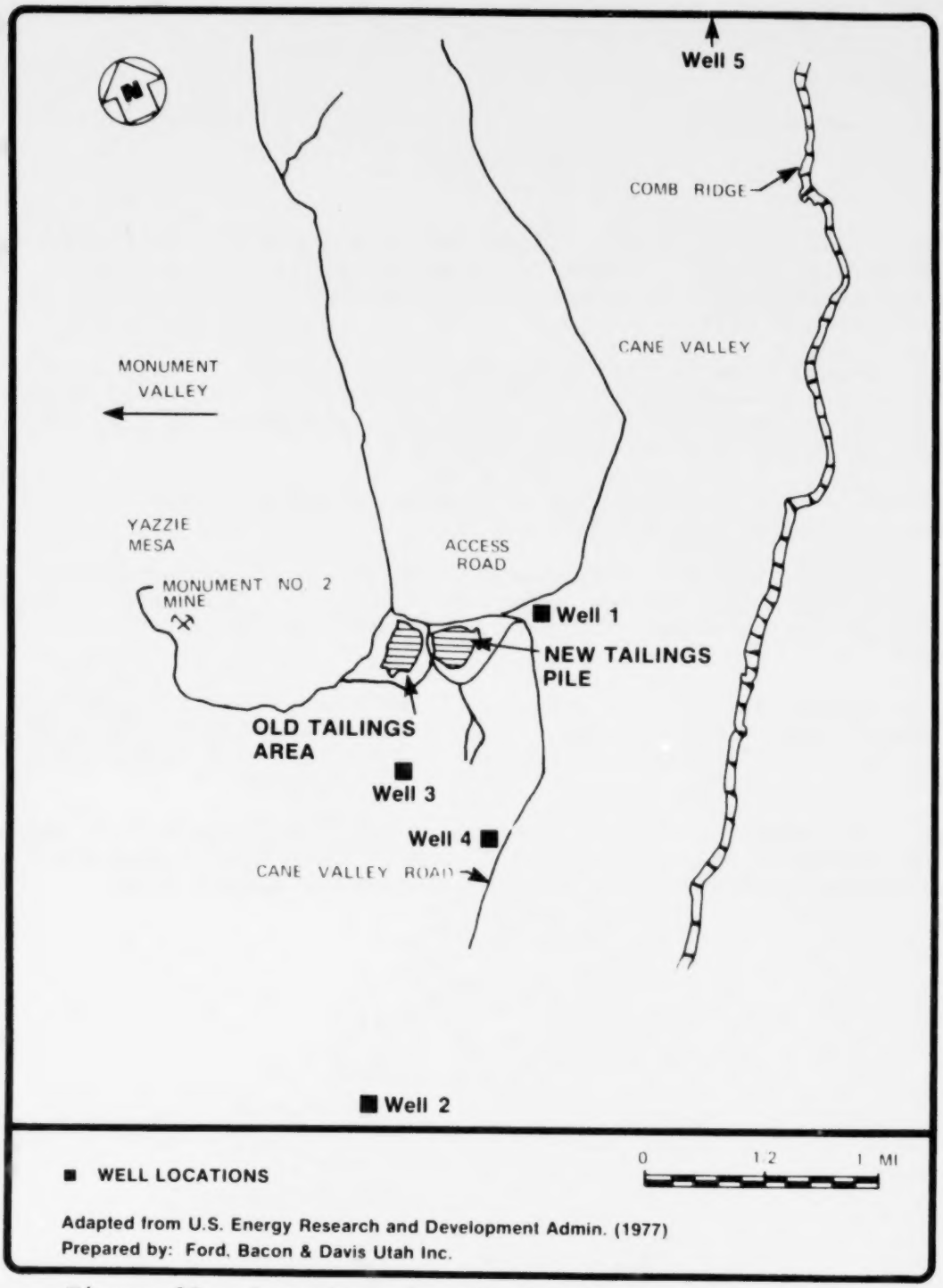

Figure 20. Location of wells in the vicinity of the former Monument Uranium Mill site

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